From the Scientific Revolution to Rock: Toward a Sociology of Feedback

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Abstract

For many people, rock's primal scene is set in a recording studio, in Memphis, in 1954. There, three musicians (Scotty Moore, Bill Black and Elvis Presley), a producer/engineer (Sam Phillips) and a tape recorder (Ampex) create a song ('All Right Mama') that durably transforms the physiognomy of music. In this article, I examine the technological, political and intellectual circumstances that made this event possible. One word holds pride of place in my discussion: feedback, a mode of organisation that originated in British scientific laboratories of the eighteenth century.[2]

[1] A great "thank you" to my sciences studies' mentors Jean-Paul Gaudillière and Ilana Löwy, to Valentine Lellouche for the drawing and to Illa Carrillo Rodríguez for the translation and (good) comments.

[2] My approach is not exclusive and is compatible with the literature that attributes Elvis Presley's sudden emergence in the music scene to economic factors [Peterson 1991], to the audience's weariness of crooners [Ward 1986] or, indeed, to Presley's and his producer's talent [Danchin 2004, Marcus 2000, Escott & Hawkins 1980 and 1991].

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Thinking Rock Techniques Through the History of Sciences

I use the tools of science studies to carry out my research. From science studies' vast corpus, I take the idea that technology is not a cold object detached from the "social" [Mayr 1986] but, rather, an *embodiment* of the ways in which societies conceptualise the world (see Hughes 1983, Shapin & Schaffer 1985, Latour 1991/97, Mindell 2002, Sterne 2003).[3] Drawn out of their (false) isolation, sciences and techniques are hence considered as agents in their own right in the social game. Science studies focus not just on scientific theories, but also on the work that is carried out in laboratories, on machines and spatial arrangements, on scientists' literary techniques [Licoppe 1996, Mondada 1995], on their relationship to power structures, etc. When a particular technique is studied, the focus is thus on the *controversies* surrounding it. The techniques that prevail in these controversies are problematised rather than presented as the inevitable outcome of such debates [Shapin & Schaffer 1985]. Moreover, in science studies, it is assumed that a single arrangement may lend itself to different uses. In other words, arrangements are thought of as having a *local* dimension. Underlying this assumption is the idea that what changes is not the "context" itself but, rather, the configuration among the entities that constitute a given situation.[4] In fact, the relationship among these entities is never definitively fixed. It is the result of a series of adjustments and compromises that are constantly renegotiated [Callon 1986]. Shapin and Schaffer [1985] set forth the idea that a society is made up of different spaces (juridical, ethical, technical, scientific, political, artistic, intellectual) that continually readjust their ways of

[3] Technology is, broadly speaking, the "social" that creaks and turns on axles or in integrated circuits!
[4] This principle is as valid for a recording device as it is for the constitution of a state, a scientific theory or a microbe [Latour 2001].

functioning and their interrelationship. I adopt their concept of "concordant spaces".

The Scientific Revolution: Regulating the World

The Scientific Revolution, which started in sixteenth-century Europe, flourished in the seventeenth century in small learned circles. Contrary to a widespread retrospective vision of the Scientific Revolution, this movement was not homogeneous and was regularly traversed by violent controversies. Furthermore, in spite of what is generally understood by the term "revolution", the advocates of natural philosophy (also known as mechanical philosophy) did not brutally sever the ties to the old ways of understanding the world. Instead, through a process that was fraught with conflict, they gradually established the bases of a new vision of the universe in which science played a crucial role [Shapin 1998]. Let us broadly summarize this movement's characteristics. Scientists initially reject the Renaissance's analogical culture, which placed human beings in a hybrid continuum composed of different entities.[5] Even though these scientists believe that universal laws – i.e., the laws of physics – govern all things and beings, they set forth the idea that only humans possess a conscience [Descola 2005]. In this vast enterprise of redistribution, classifications hold pride of place. Thus, botany divides plants into species, identifies their characteristics – for example, their modes of reproduction –, studies their diverse components and represents them on *planches botaniques* (colour plates). Moreover, separation is undoubtedly the governing principle of the new doctrine, whose different variants are all grounded in a common method that *isolates things*. As Sterne [2003] has convincingly demonstrated through the example of sound, this method prepares the ground for the emergence of entities

[5] An example of such an intertwining of hybrid objects is the aristocrat's coat of arms.

that are studied in and for themselves. Logically, this operation on objects is accompanied by the progressive constitution of disciplines with their specific methods and literature.

Scientists of the seventeenth and eighteenth centuries conceive nature as their principal object of study, the locus where the answers to their questions are found. Thus, they devote themselves to the observation of nature, making use of their new equipment, and attempt to reveal the (physical) laws that govern the universe. It is worth noting, in passing, that the virtual idealisation of (Mother) nature is concomitant with its feminisation. This assimilation is not trivial since the feminine is associated with the rhythms of nature, intuition, passivity and stasis, while the masculine is identified with knowledge, initiative and – it goes without saying – the ability to decipher mysteries [Gardey and Löwy et al. 2000, Löwy 2006].

To take the *measure of the world*, it is, of course, necessary to be able to compare what is comparable. The creation of universal standards becomes necessary; hence the importance of having at one's disposal standardised systems of measurement and appropriate spaces of representation. To ensure this, the task of summarizing physical laws in formulas and equations is assigned to mathematics, and geometry is entrusted with the task of translating this order into the space of the plane. Favourite among favourites, the (Cartesian) table is the image that expresses the mathematical operation through which an average is obtained from two variables. The score is a good example of this simultaneous task of the reduction and "universalisation" of a practice.[6] Using two parameters (pitch and duration), the diagram (Figure 1) represents an average called "music". As if with a barometer or thermometer, music is measured and, therefore, reproducible. When music is transformed into a

[6] Translator's note: The French word for "score" (*partition*) means "to separate" and, thus, clearly evokes the method of isolating things and the idea of division or segmentation which underlies the double process of reduction and universalisation described above.

measurable object, it also becomes a commodity that can be bought and sold in the market.

p
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(ordinate)

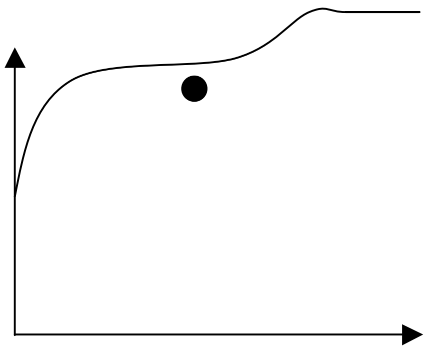

Figure 1 **duration** (abscissa)

The score by J.S Bach below (Figure 2) represents the same process. The music page, which resembles a chequer-work, allows for the visualisation of five lines (the staff), within which notes are placed. The clef placed at the beginning of the staff provides information concerning the average value, from which the pitch of the notes is deduced. However, when certain notes are too high or low to fit within the staff, lines are added above and below it; this means that *part of the chequer-work is revealed*. If an entire passage departs too much from the general organisation, the clef is changed. Finally, the function of the chequer-work is also to fix a temporal framework. A fraction (for example, 3/4) placed at the beginning of the score – which is also an average – tells the performer how many time units there are in a *bar*. As for the pitch, the invisible chequer-work subdivides the bar measure into equal and proportional segments. And even if the bar's size varies according to the number of notes that are placed in it, the time reference remains unchanged. Though much more could be said on this subject, the formidable efficiency of this organisation is evident. One of its greatest assets is that it is not only a system, but above all, a way of organising music and of representing it through values and symbols.

Figure 2[7] (The horizontal lines represent pitch, while the vertical lines divide the duration into equal sequences.)

Equipping Knowledge

As Galileo's famous astronomical telescope reminds us, this modelling of the world is accompanied by the development of instruments that function as prostheses of the senses, which scientists mistrust. In fact, the project *to instrumentalise knowledge and human activities – to equip knowledge –* characterises the Scientific Revolution. Before returning to this point, I would like to note that the will to equip knowledge grew largely in parallel to the rapid development of clocks and their installation in public and domestic spaces. From the sixteenth century onwards, clocks increasingly became a part of the public

[7] I have used the tables that appear above in an article on musical measure to be published in 2007 in the journal, *Enseigner la Musique*. The score is taken from "Invention No. 8" by J.S. Bach BWV 779.

and domestic spaces and acquired considerable power [Mayr 1985, Landes 1983]. They are real instruments of knowledge, on which beautiful automatons or the movement of the planets are represented; the movement of their mechanisms is a spectacle in itself. Likewise, they are a metaphoric force. Clocks serve to represent the power of the Creator (the great clockmaker); scientists compare their workings to the universe (and vice versa); and the pendulum's regular rhythm inspires a new vocabulary that includes words like punctuality and accuracy (particularly in reference to scientists' accuracy).[8] The clockmaker metaphor owes its longevity to the power that determines the domestication of time. Standardised time, the implacable regulator of human activities, makes possible the synchronisation of transport and production, the measurement of work (-time) and, before long, the calculation, by means of the maritime clock, of the path of colonial expeditions [Landes 1983, Despoix 2003]. The clock is, therefore, not only a metaphor for the universe, but also an instrument of coercion that confers power over things and beings [Elias 1996].[9] Natural philosophers subscribe to the idea that a guiding principle governs the world. This is undoubtedly why they compare nature to a perfectly regulated clock, the human or animal body to an automaton (Descartes), and the State to a mechanism governed by a sovereign who acts as guarantor of the common interest (Hobbes). Moreover, they assign to themselves the role of revealing (with all due modesty and complete objectivity) the world's immanent workings.

Having broadly defined the common background of the architects of the Scientific Revolution, I will now examine the crises that unsettled this community. Through an analysis of the discrepancies concerning the role of

[8] This shows that measure not only concerns scientific work or machines, but also social behaviour.
[9] Thus, the rabbit in *Alice in Wonderland* expresses his fear for his life by referring to the clock's dial. He knows, indeed, that the hand of his alarm clock ticks at the same pace as that of his bloodthirsty queen.

machines and tools, I will show how two local conceptions of science took shape.

Major (dis) Cords on Both Sides of the Channel

It is possible to situate in the seventeenth century the progressive development of a British variant of natural philosophy that intensifies science's instrumental dimension and turns the *laboratory* into its main locus. The practice of going outdoors to observe natural phenomena is undermined by the attempt to *model* the laws that govern matter. Robert Boyle, the father of modern chemistry, confers on his machines the power to *reproduce* experiments. "Trustworthy" (i.e., aristocratic) witnesses attest to the precision of these machines in their ledgers. Like his colleagues at the Royal Society, Boyle only trusts "matters of fact" and refuses dogmatic debates. He thus lays the foundation for a pragmatic science, in which peers validate results and scientists can claim to represent the common interest and the king [Shapin 1998, Shapin and Schaffer 1985]. In this sense, the experimenter Boyle is faithful to Bacon, who in his work *New Atlantis* (1627), predicted the advent of an ideal city governed by scientists, in which technical innovations would ensure tranquillity and comfort for all. In a passage of his book, Bacon evokes something that to a surprising extent resembles the (future) recording studio:

> "We have also sound-houses, where we practise and demonstrate all sounds and their generation".

The mixing desk and P.A. system:

> "We represent small sounds as great and deep, likewise great sounds extenuate and sharp; we make divers tremblings and warblings of sounds, which in their original are entire".

Headphones and spatialisation effects:

> “We have certain helps which, set to ear, do further the hearing greatly; we have also divers strange and artificial echoes, reflecting the voice many times, and, as it were, tossing it”.

And even the radio and the telephone:

> “We have all means to convey sounds in trunks and pipes, in strange lines and distances”[10]
>
> [http://oregonstate.edu/instruct/phl302/texts/bacon/atlantis.html]

Even the austere theorist Newton resorts to machines of his own invention to validate his theory of universal gravity [Jacob & Stewart 2004]. Inseparable from the machine, the laboratory – which will soon become a “scientific laboratory” – becomes the site where nature and its laws manifest themselves. The *machine becomes the active principle of knowledge*, to the great displeasure of the Continent’s Cartesians (represented in England by Hobbes), who consider that the machine’s function is to control the accuracy of calculations and to serve as a referent in the process of observation of external phenomena.

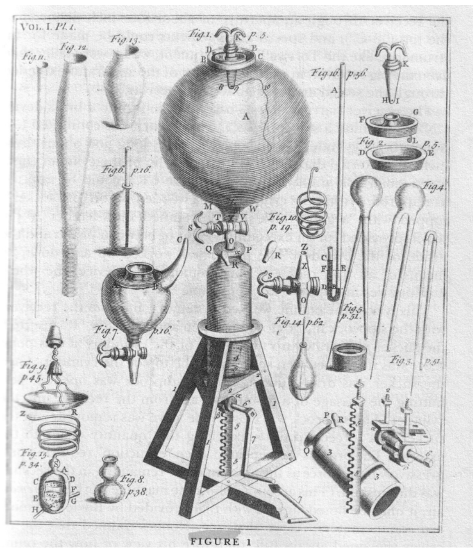

Figure 3 Boyle’s Air Pump and instruments

[10] Quoted from the Internet Wiretap edition : [http://oregonstate.edu/instruct/phl302/texts/bacon/atlantis.html]

Regulation versus Precision

The increasing opposition between the Continent's scientists and (the perfidious) Albion does not reflect purely epistemological questions. This opposition refers, rather, to the ways in which scientists construct their social legitimacy. If protocols and demonstrations diverge, it is also because English scientists are not forced to present their experiments to the same social groups as French scientists are. Through a close reading of the experiment records of the seventeenth and eighteenth centuries, Licoppe [1996] shows how national differences were created and consolidated.[11]

National specificities also manifest themselves in technological matters [Mayr 1986, Landes 1983]. While the French and Germans specialise in mechanisms of precision and clocks, the British focus on *feedback devices*, that is to say, on self-regulating systems. The systems that regulate the speed of water-mills and steam-engines are good examples of their achievements in this domain. Feedback allows an organism to listen to itself and, thereby, to optimise its results. To do this, the machine must be capable of *discerning* within itself certain types of signals and of neglecting others, a process that electrical engineers will later call the "signal-to-noise ratio" [Serres 1980, Mindell 2002]. In cognitive terms, this means that the machine is endowed with reflexivity or, to use the metaphor of *audition* (hearing), that it is simultaneously equipped with an internal and an external ear. We once again encounter the Cartesian idea that posits the correlation between machine and human body. This time around, however, it is the latter that serves as a model for the former. This illustrates the difference between the Continental and British views: while the former privileges the guiding principle, the latter emphasises the crucial role of equilibrium. In short, *whereas Cartesian logic seeks to mechanically describe things, Newtonian logic strives to anticipate systems' behaviour*.

[11] Of course, France also has its theorists of equilibrium (for example, Lavoisier) and of instrumental excellence. However, the difference between the two countries lies in the *functions* assigned to, and the *ways* of accounting for, experiments.

This scientific and technological antagonism has its political counterpart. While French philosophers justify the existence of an uncontested central authority, whose avatars are absolute monarchy and enlightened (revolutionary) despotism, English theorists, influenced by a succession of civil wars, advocate the balance of power, restrictions on royal sovereignty and (relative) religious liberty. Mayr has lucidly argued that Adam Smith's famous "invisible hand", which "naturally" regulates the market, is part of this politico-technological tradition. For Smith, the invisible chequer-work that represents music on the score therefore becomes an *active principle*; an immanent structure corrects the system's errors and guarantees its proper functioning. To assert that this conception is "intrinsically" British would, of course, be an excessively essentialist assumption. Nonetheless, there is no doubt that, beginning in the seventeenth century, this conception holds pride of place in the British way of representing and fashioning the world.

The Metamorphoses of Newton (and His Theory)

As I discussed earlier, the type of experiments carried out and ways of accounting for them relate to the strategies scientists use to validate their work to the social agents (political power and patrons) from whom they must obtain support. Moreover, I emphasised British scientists' tendency to assign to machines the task of proving their hypotheses. The conjunction of these two factors resulted in what researchers have called *the instrumental version of the Newtonian doctrine*.

> "The construction of truth (...) is henceforth organised around philosophers' ability to convincingly represent the decontextualisation of tools or of the way in they account for their experiments. In this way, philosophers expand their field of operation beyond the laboratory, and their resources can, thus, be used as practical tools by a broader public. *Hence, not only simple accounts are interchangeable, but also the*

> *representations of tools and at least some of the forms of know-how that allow for the most advantageous disciplining of the new material practices*". [Licoppe 1996 p. 157; emphasis added]

Scientists adapt their know-how for its diffusion in, and translation into, the public sphere. Hereafter, experiments are aimed less at validating locally obtained "results" than at deducing *the general principles of mechanics*. Jacob and Stewart [2004] have shown how scientists' public performances in coffee-houses and wealthy residences gave rise to a new scientific audience. The main purpose of these experiments, which were usually based on electricity, was to attract entrepreneurs and financiers. Indeed, many notables and entrepreneurs participated in the foundation of Newtonian societies in their hometowns. Rather than his equations and theories of gravity, which remained obscure to most of his contemporaries, it was the instrumental aspect of Newton's theories – he studied in particular questions of optics – that acquired a following. The flourishing of this mechanistic frenzy contributed in a decisive fashion to a rapid industrial expansion. This dazzling expansion depended, of course, on innovations like the system of control of the speed of water-mills and the development of weaving looms and steam-engines. Needless to say, from the eighteenth century onwards, the industrial boom would transform the British Isles into the foremost industrial power [Mougel 1997, Chassaigne 2001, Mayr 1987]. Moreover, in addition to the rise of a working-class, the boom of "modern" industry was concomitant with the birth of a profession that conceived, repaired and, above all, apprehended the world through, machines: engineers.

Birth of a Profession

Before I pursue my journey across the Atlantic, I would like to recall that engineers existed before they were designated as such. Thus, in 1764, a carpenter called Harrison received (part of) a prize, which the English Parliament had offered to the person who could conceive a tool for measuring longitude. After three consecutive trials, Harrison succeeded in building a maritime clock (or marine timekeeper) that was resistant both to storms and to the instability onboard ships. This tool allowed ships to determine their position on a map; in other words, it became possible to plot a position (i.e., to determine the average) by jointly using longitude and latitude.[12] What is so remarkable about this is that a carpenter from Yorkshire succeeded in taking up the technological challenge whose terms had been set forth by Newton himself before the members of Parliament [Despoix 2005]. Bloody hell! An outsider managed to solve an enigma that many scientists of his time considered to be unsolvable! Even though Landes presents the genius of Harrison, the "self-taught clockmaker", as a mystery, he nonetheless furnishes the solution to this enigma:

> "John Harrison presumably learned about clocks by fixing them (...) *From repairing, Harrison went to building*. His first clocks were conventional, but after the announcement of the Great Prize, news of which reached even to Barrow, he set about with his brother James to build clocks of a higher degree of precision, *clocks that would be a testing ground for ideas that might later be incorporated in a ship's timekeeper*. (...) But it should not be thought that Harrison was ignorant of what we would call scientific principles. Someone, presumably a visiting minister, lent him a copy of Nicholas Saunderson's lectures on natural philosophy at Cambridge University *[Nicholas Saunderson was the inventor of a calculator*], and Harrison found these so valuable that he copied text and diagrams *in extenso* for his own use". [Landes 1983 pp. 160-161; my emphases]

[12] This is a good example of the conjunction between the Cartesian diagram and the tool for the measurement of time – a conjunction that evokes, in many respects, another couplet: the musical score and the metronome [Ribac 2007].

Landes's account illustrates the process of knowledge transfer described by Jacob & Stewart [2004], Licoppe [1996] and Layton [1983]. In fact, it is highly probable that the lectures copied by Harrison were devoted to the principles of mechanics and therefore extremely useful for his research. Landes notes that, in addition to the text, Saunderson's lectures included diagrams. There is nothing surprising about this, since the engineer's knowledge consists in actualising the principles of mechanics (and vice versa). Thus, it would be only partially accurate to describe Harrison as a self-taught man; he was self-taught only insofar as he did not attend clock-making school or belong to the Royal Society. Nonetheless, Harrison did attend the school of machines. His experience as a carpenter familiarised him with assemblage, and the repair and construction of clocks were his practical and theoretical introduction to mechanics. Later on, he used his prototypes of the maritime clock to solve specific problems and, finally, to give shape to a new escapement mechanism, whose principles he *intuited* very early on.

Benjamin Franklin's story is similar. This "self-taught man" undertook electrical experiments that eventually led him to the invention of the lightning conductor, which made him famous and earned him both Robespierre's and Marat's admiration.[13] He developed his belief in the electrical nature of lightning on the basis of his experiments [Beltran 1991]. Edison followed the same path. He was a young news-vendor who worked on a line of trains, when he started to carry out experiments (in a wagon converted into a makeshift laboratory) and to learn about the telegraph. As for Robert Moog, he learned electronics by repairing Theremins with his father.[14]

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[13] If we take into account Franklin's "empirical" training and way of practising science and justifying his experiments, we can describe him as a representative of the instrumental current of the Newtonian school.

[14] The theremin is an electronic musical instrument in which the tone is generated by two high-frequency oscillators and the pitch controlled by the movement of the performer's hand towards and away from the circuit .

Even though these innovators did not receive a formal academic training, they attended the school of machines, which can (and ought to) be regarded as their *instructors*.[15] And like Harrison, they did not hesitate to complete their experiments by reading scientific treatises; Edison even hired academics to work in his laboratories at Menlo Park [Hughes 1983]. Thus, it becomes clear that these engineers/inventors succeeded in "performing" machines precisely because they thought in terms of springs and cogs. Edison confirms this analysis:

> "I have the right principle and am on the right track, but time, hard work and good luck are necessary too. It has been just so in all my inventions. The first step is an intuition, and comes with a burst, then difficulties arise [cited in Hughes 1983, p. 33]

If we move forward a century and a half, we can listen to Robert Moog in a documentary devoted to him:

> "*I can feel what is happening in the electronic components.* I have a sort of instinct... *I know what is taking place inside a transistor and a resistor*. I can think about a problem I have to solve for days and weeks, without anything happening, and one day, while I am mowing the lawn or eating a hamburger, or when I wake up in the middle of the night, the idea will be there (...) *It is something between discovering and witnessing*". ["Moog" 2005, film by Hans Fjellestad; my emphases]

In the same way that Harrison probably *envisioned* his escapement mechanism even before figuring out the shape it would take and Edison *intuited* the principle of an invention, Robert Moog imagines the electrical fluxes running through integrated circuits, whose moods he knows so well and whose potentialities he senses [Pinch & Trocco 2002, Pinch 2005]. It is as though, for him, his discoveries were inscribed in the way of functioning of the electronic

15 For engineers (and musicians of popular music), recording has the same function as printed books had in the Renaissance and the Enlightenment [Eisenstein 1991 and Ribac 2005].

labyrinths. We, in turn, see an *Anglo-Saxon technical culture* – a genealogy that goes from Boyle and Harrison, to Edison and Moog – taking shape. That's quite something! Let us broadly define this tradition, which originated in British experimental science:

This scientific culture is opposed to Cartesian dogmatism. It assigns to machines the task of representing "natural" phenomena and turns to entrepreneurs to guarantee economic development.[16] In this culture, engineers' world-view is increasingly dominant. Moreover, this is a (political) culture that is based on the balance of power and that privileges systems' autonomy and self-regulation.

Let us examine now how this culture evolved when it was exported to Britain's North American colonies. We shall change continents and attempt to find the traces of the culture of feedback in twentieth-century American electrical and electronic industries.

Research and Development

The references to British coffee-house demonstrations and to Benjamin Franklin's experiments remind us of *electricity's central role*. Like clocks, electricity was initially regarded as a curiosity but later came to be considered as energy. As such, it would become the undisputed favourite in the World Fairs of the nineteenth and twentieth centuries and would feed turbines, the tubes of physics laboratories and many innovations. The itineraries of two major American electrical firms – General Electric (GE), founded by Edison, and AT&T, an outgrowth of Alexander Graham Bell's consortium – attest to electricity's central role in the development of an engineering culture of feedback. In his history of these companies' research laboratories, Reich [1985] shows how GE and AT&T, gradually and in a similar way, built their success on

[16] On this subject, it is worth noting that in *The Protestant Ethic and the Spirit of Capitalism* [1904-1905] Max Weber presents Benjamin Franklin as the prototype of the entrepreneur.

their capacity for innovation. Reich points out that it took some time before the idea of investing large sums of money in research and development laboratories became dominant. Laboratories started to recruit physicists and chemists trained in the Newtonian school in order to contend with the problems that engineers were unable to solve. An initial hierarchical conception, in which the company dictated the direction the research was to take, was replaced by more flexible forms of organisation that paved the way for initiative and innovation. Even though these laboratories had been originally created to protect the companies' interests (particularly their patents), they started to publish the results of their research and to actively cooperate with academics. Thus, GE's and AT&T's laboratories developed the ability to conceive and successfully realise innovations that ensured these companies' predominance in the market for decades (in electric lighting, telephony, phonography, telegraphy, radio and broadcasting, and television).

In *Between human and machine: feedback, control, and computing before cybernetics* [2002], Mindell shows how cooperation played a key role in American research. He examines the period between World War I and World War II, during which the American government mobilised industrial laboratories – particularly Bell – and public research to improve both systems of weapon detection and weapons that could destroy enemy targets (ships, planes and missiles). Mindell's book describes how work groups were organised around research topics and examines the way in which the directors of these work groups succeeded in promoting researchers' and engineers' creativity and dialogue between disciplines. Mindell's study not only describes the modus operandi of these research structures, but also draws attention to the technological conception of the instruments of detection. He shows how *feedback came to represent, for engineers of the 1940s, a conceptual principle that could be applied to all kinds of domains*. Let us examine certain aspects of this.

In order to destroy a moving target, it is necessary to locate it, to analyse its movement and to calculate its trajectory. Basing his demonstration on the example of air defence, which can be applied generally, Mindell traces the shift from a *mechanical logic* – in which the movement of the observation turrets is analogically translated and produces a forecast of the target's movement – to *digital systems*, in which trajectories are described by means of symbols and inform the decision.[17] These digital systems prefigure the computer, since the target's movements are *translated* into data and analysed; the target's movements also guide the machine's firing. In this system, the detector's different components enter into dialogue with each other and constantly readjust the parameters that lead to a decision. They use feedback to regulate their own movement and actions. If Cartesian tables are still present in these systems, particularly in the monitor screens of radars, it is to display calculations that are carried out in a space that is different from that of geometry. In fact, the transition here is from a logic based on mechanical subordination (*servo mechanism*) to "a marriage between control and communication" (Mindell). These methods – of which different types of instruments are the embodiment – not only represent a technological advance, but also reflect a political vision, since, to paraphrase Mindell, *these systems consist in representing the world with symbols and in manipulating those symbols* (p. 3). It is, thus, reasonable to characterise them as the translation into hardware of engineers' world-view.

The "marriage between control and communication", to which I just alluded, is, in particular, the result of research on transmission and waves undertaken especially in the Bell laboratories. By resorting to the principle known as "negative feedback", engineers succeeded in amplifying the signal and in simultaneously attenuating the noise generated by the means of transport and the medium. Then, by transmitting the coding of conversations, rather than the

[17] Mindell explains, however, that the analogical does not disappear into the digital logic. On this point, related to recording practice, see Kvifte [2006].

conversations themselves, transmission engineers laid the foundations of digital technologies and of information theory, which is based on the assumption that it is possible to convert all information into data, to transmit it and to decode it upon reception.

There is yet another connection between the world of electricity and the development of a general theory of feedback. In fact, the possibility of inferring information from an object's movements is largely due to the experiments performed with *vacuum tubes* in the physics laboratories of the electrical industry.[18] In these laboratories, successful attempts were made to isolate waves, to amplify their signal, to measure the wavelengths and to transmit the waves from a distance (as is done in radio, for example). It then became possible to detect an object from data analysed by machines. The vacuum tubes allowed radars to analyse the trajectory of an object and to convert this data into a decision. It was with these very same vacuum tubes that sound was amplified and transported from one part of the world to the other; in the mid-1920s in conjunction with the electrification of gramophones. In other words, it is perfectly possible to tell the history of feedback through the successive metamorphoses of these rarefied spaces.[19] *And the first tube that would appear in this genealogy is the air pump into which Boyle introduced birds or plants before removing from it as much air as possible*. The history of feedback could also be told from the perspective of laboratories. The scientific laboratory of the seventeenth century appears as the ancestor of the radio broadcast control room (Figure 4) and the recording studio, which are arrangements that can be defined as *spaces in which humans and machines collaborate.* These collaborative spaces are made up of instruments whose function is to represent music,

[18] Edwin H. Armstrong is generally credited with having developed, in 1912, a feedback or regenerative circuit that amplified signals. The improvement of this circuit is attributed to De Forest, who developed the "audion tube" from it. In 1915, AT&T succeeded in broadcasting a human voice on the East and West coasts of the United States [Hilliard and Keith 1997, p. 14-15].

[19] From this point of view, and although my approach is different, I agree with Paul Théberge's conception of the studio as a "non space" [2004], that is to say, a space whose sounds and dimensions can be modulated. "Non space" refers also to the fact that there is no air in the (*vacuum*) tube.

manipulate its different parameters and break up into distinct stages the process through which music is made. British natural philosophy, which was concerned to reproduce natural phenomena, thus becomes a means of (re)producing the world of sound—just as Bacon predicted!

Plate 25. Interior of AT&T radio broadcast control room, Washinton, D.C., 1923. Reprinted with permission of AT&T Corporate Archive.

Figure 4 AT&T Control Room, 1923

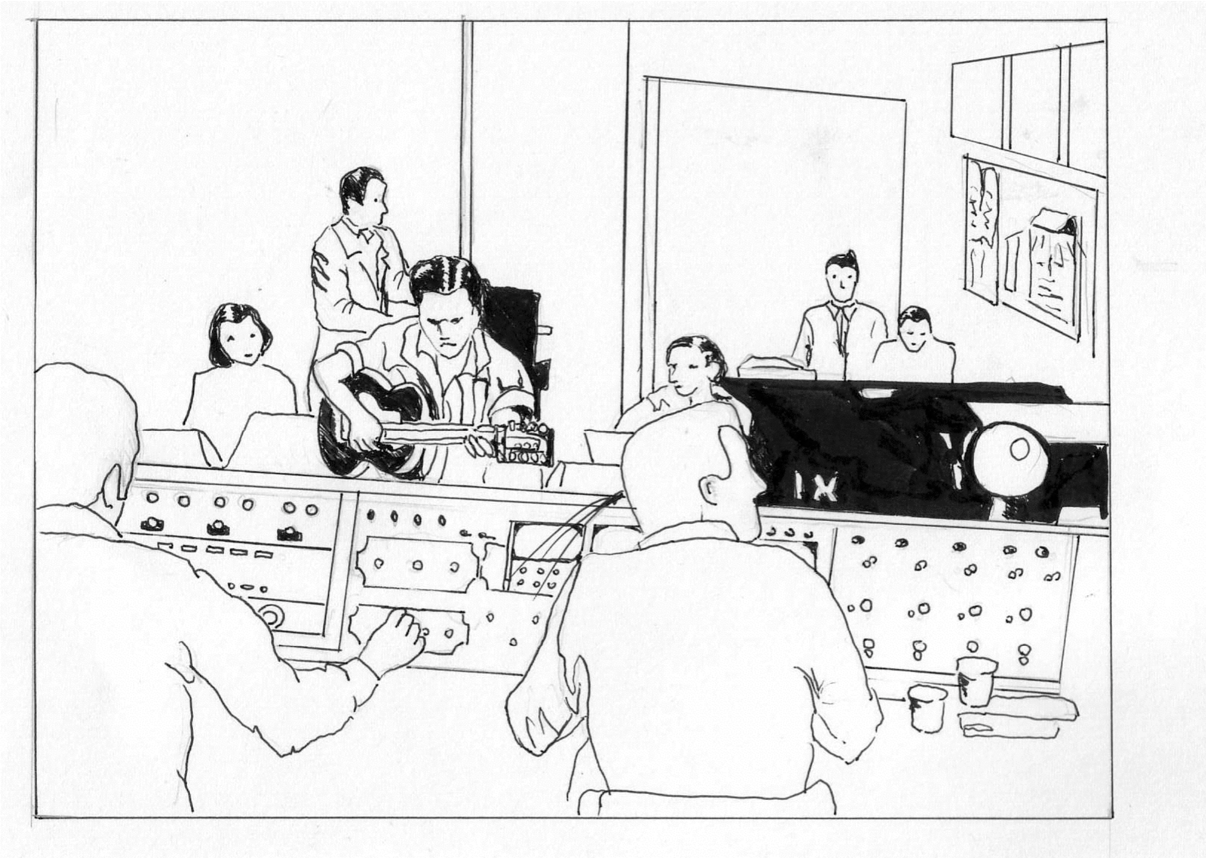

Figure 5 Reproduction of a scene from Richard Thorpe's film *Jailhouse Rock* (1957). Drawing by Valentine Lellouche.

Elvis's House

At the end of this journey, the above drawing of a scene from Richard Thorpe's 1957 film *Jailhouse Rock* provides a considerable amount of information. This cinematographic representation of rock's foundational scene (Elvis Presley's first recording) is recreated by some of this scene's original protagonists (Elvis and his musicians) three years after it actually took place.[20] Hence it holds a particular interest for my discussion. What a stroke of luck, indeed! Is there a historian of the nineteenth century who has had the privilege to see Napoleon recreating Waterloo? Of course, the idea that everything started in a single moment is hardly scientific. However, this reconstruction will allow

[20] Of course the studio scene in *Jailhouse Rock* is not a literal reconstruction of the Sun studio site or occasion of Elvis's first recording sessions. But it does represent the significance of those sessions, which is how I here understand it.

me to show how this situation is paradigmatic and in what ways the (technical and human) actors in this scene are connected to the tradition that I have previously described (without underestimating the protagonists' capacity for initiative and their genius, of course). Let us examine, then, the scene depicted above.

The spatial lay-out is based on the *separation* between "those that record" and "those who are recorded", between the control room and the recording room. A pane of glass ensures the airtightness between the two spheres and allows the protagonists in one of the spheres to carry out their work without disturbing those in the other.[21] This lay-out ensures that the music will be isolated from all sorts of parasitic noises that could disrupt the *sound recording*. The recording of sound is dealt with as a separate entity and is called *modulation*, which means that it is characterised as a variant of energy. The white coats of the two characters in the foreground indicate that they are technicians. To be more precise, they are *sound engineers*, that is to say, people who manipulate the "sound" entity and use specific instruments to measure it. The engineer on the left operates the buttons on the *control panel*, while his colleague verifies whether or not the instrument that records results works properly. The tape recorder – which is the name of this object – is a sort of (plebeian) electrical witness that notes down on registers (magnetic tapes) the music that is performed -in the lab- by the band. When we look closely at the entrails of the tape recorder and the various other devices that are laid out in the control room (whose ancestor is represented in Figure 4), we see many (vacuum) tubes warming up and spitting out waves. In a process that recalls the way in which microbe culture is studied in scientific laboratories [Latour 2001], these tubes amplify the electrical signal that comes from the microphones and inject it into the mix table's circuits and tracks. Through these tubes, Elvis's

[21] In professional studios of the 1960s, this trend became dominant and led to the practice of placing each musician in a separate room and of using mobile compartments.

voice is isolated from the instruments; then it is processed, cleaned, reverberated and, finally, sent to the tape recorder. During the recording session, listening devices (loudspeakers and the P.A. system) convey the sounds from the recording cabin to the control room where the technicians are.[22] This principle of re-diffusion (called *monitoring*) is used during, as well as after, the musical performance. In Thorpe's film, a song, which is at first considered to be deficient by everybody, is played once again. Then, the nugget finally emerges and is caught by the sieve/tape recorder. It does not really matter that, in the "real scene", in the Sun studio in 1954, such divine inspiration was the outcome of a moment of improvisation during a break. The principle remains the same: the system is conceived in such a way that, at all times, the users in both rooms are in a position to control, through reatroaction, what is being (or has been) produced. Reflexivity is thus inscribed into the session's modus operandi and (as we now know) into the culture of the protagonists we observe. In the discussion concerning the quality of the music, *recording devices and filters assist humans and guide their decision*.

This discussion draws our attention to the woman beside Elvis, who is Presley's producer and/or agent. She has noticed the young talented man in a bar and has arranged for the studio session. She actively participates in the discussions concerning the quality of the takes and keeps an eye on the technicians. At the end of the session, she will attempt to convince the artistic director of a label that the song which has been recorded can become a hit. This relates to the narrative of *Jailhouse Rock* rather than to Presley's own story. His first recording session was produced Sam Phillips, who owned Memphis's Sun Record label and had been trained in the world of radio. Phillips not only conducted Elvis's session but was also in charge of the control room. It was

[22] In the 1960s, the practices of monitoring and of equipping performers with headphones became generalised. Later on, monitor speakers would allow musicians to listen to themselves independently of what is presented to the audience. It is worth noting that headphones were first used by telegraphists and armies' radio transmitters; the stethoscope is their forebear [Sterne 2003]. In this case, the common genealogy that connects techniques of reproduction with science is manifest.

Phillips who used two tape recorders to develop an echo system (often called *ping-pong effect*) that would become rockabilly's sound signature [Escott and Hawkins 1980 and 1991]. It was Phillips who, after listening to the tapes again, decided to release and promote *All Right Mama*. And Phillips's training, career itinerary, skills and attributes support my argument: one could say that Phillips' .ultimate goal was *to legitimate his experiments in the public sphere*.

And the artists? Are you not going to speak of them? That would be the height of absurdity! Patience, I am coming to them.

A "Historical" Junction

The artists barely know each other before this inaugural recording session. At Sam Phillips's request, Elvis met once with the guitarist and the double bass player.The trio arrived at the studio without really knowing what to play and experienced difficulties, it seems, in deciding how to perform the songs, which they selected with Phillips as they went along. According to rock historians, Elvis was humming some sort of tune in a corridor, during a break, and Phillips, *as chance would have it*, heard him and asked him to record it [see, for example, Marcus 2000]. On this point, historians are mistaken, for it is the *method* that I described above – and, by no means, chance – that made this possible! Presley and Phillips obtained this result precisely because they transformed the studio into their house.

From this perspective, *Jailhouse Rock's* fictional recording session is more relevant than historical truth. For popular musicians have something in common with the electrical industry's engineering culture: they carry out their work step by step, gradually adding elements to those proposed by their partners, thus engaging in a form of bricolage that is based on the double process of addition and dialogue. In other words, they depend neither on a conductor nor on a Cartesian diagram. Instead, bodies and, when necessary, specialists (the rhythm section) supply the pulsation and ensure coordination. In the same way, bodies memorise the gestures and the music's structure. The popular way has, thus, merged with the method that assigns to machines the task of coordinating activities and of analysing and processing operations. Furthermore, while in the pre-electricity era pop musicians were given feedback on their work by their audience and each other, in the studio the producer (literally) assumes the role of the audience. During recording sessions, s/he gives performers feedback on the quality of the performance and on the possibility of finding an audience for it [Hennion 1981]. Another crucial collaborator, the tape recorder, allows humans to reflect on what they have produced and, thus, to deduce and explore alternative directions for their work. Indeed, Elvis and his accompanists transformed the studio into their *new rehearsal space*. Unlike classical musicians, who go to the studio to record a repertory that has been previously prepared and perfected, and unlike jazz musicians, who improvise in the studio almost like they do in concerts, engineering culture and popular music created a new, hybrid temporality that is at least as efficient as the score was in the past.

The Beatles slept in Abbey Road because the studio is rock's laboratory, and tape recorders are its air pumps. I argue against the idea that the Beatles started to use the studio as a tool only when certain technical means (the four-track tape recorders) were placed at their disposal. It would be more accurate to say that they turned the studio into a tool when *George Martin allowed them to work in Abbey Road in the same way they did in their rehearsal locale*. Moreover, according to Martin's memoirs, he had already started to "tinker around" in the studios with Peter Sellers and the engineers at EMI [Martin & Hornsby 1979]. If McCartney sometimes arrived to the sessions with only a few ideas in mind, and if Lennon asked Martin for arrangements and then failed to show up in the studio for several days, it is because the culture of real time (or of immediate performance) corresponded neither to the engineers', nor to the rockers', modus operandi. Presley's successors came to grips with machines in the same way that Harrison, the carpenter, had come to control clocks. By working in and tinkering with studios for hours (as we do nowadays with computers), they succeeded in recording *I Am the Walrus*.

Has one of the cultures sworn allegiance to the other? No, because each band, each producer negotiates (sometimes very harshly, sometimes miraculously) with its partners. And as we learn from rock records (and from the saga that precedes them), feedback is not fixed in eternal forms. Feedback has even become a *sound aesthetic* under Jimi Hendrix's fingers and those of countless unknowns. Hence, something unprecedented has taken place: sound engineers have collaborated with "self-taught" people to produce noise and saturation, that is to say, to amplify those damned parasites that, for two centuries, generations of engineers endeavoured to annihilate! In other words, the tradition of feedback, like all other traditions, has its local *avatars* and its own revolutions. Rock is the result of an encounter, which was consummated in a marriage that produced a great many children, among them, hip hop and techno.

In one of his books, Bateson [1977] puts forth the idea that it is only possible to understand an organism if we pay attention to the signals it sends. Remarkably, he justifies his theory through a sundry set of examples that draws as much from the way in which Alcoholics Anonymous functions as from the modus operandi of Asian societies. Likewise, popular (technical) culture invents itself, and continually recreates the self-regulation that characterises it, in extremely diverse spaces. These "original versions" of feedback are also present in the Internet's (moderated) chat rooms; in the visitors' books (the "Comments" section) that appear on bands' web sites; in the ways in which audiences become involved in, and react to, group events; in the loops of techno D.J.s; or in the dominant place that dialogue occupies in the musical structures and arrangements of popular music (for example, the conversation between backing and lead vocals). The homology between the clockmaker Harrison and the young Liverpool guitarist, whose name is written in almost the same way, is, after all, not merely formal. If I had to define in one sentence the relationship between these two outsiders, I would say that they are both human beings who succeeded in transforming machines into their collaborators. For our greatest pleasure!

Translated from the French by Illa Carrillo Rodríguez

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[23] For works in translation, I have given the date in which the French-language version was published.

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